Carbon cycle impacts of plantation land-owners as joint producers of timber and fuel: towards incentive-compatible modeling of land use change policy impacts.

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motivation springs from related paper

**Bio-Energy with Carbon Storage (BECS):
a Sequential Decision Approach to the threat of
Abrupt Climate Change**

Peter Read and Jonathan Lermit

(For presentation at International Association

of Energy Economists, Prague, June 4-7)

By way of motivation for this presentation: why model landowner behavior?
A back of Envelope calculation

Energy security

500 GJ/Ha-yr x 500 million Ha = 250 EJ annually
[[half current best commercial practice in Brazil
x
40 per cent of cultivable land said by IPCC to be
available after allowing for growing food supplies]]

**30 per cent conversion displaces 75 EJ gasoline annually**
= 120 EJ crude   (assuming 5/8 high value fractions)
= 12,000EJ per century = 12,000 x 24 mtoe
= ~ 2.2 millions of millions of barrels of oil, over twice global proved reserves
Say 1½ allowing for a slow start in first few decades.

Policy driven global land allocations under a 'be prepared For Abrupt Climate Change with and without precursor signals two decades hence (H=nature horrid, N=nature nice)

Land use responses to states of nature under precautionary polic

Time after start (2005?)
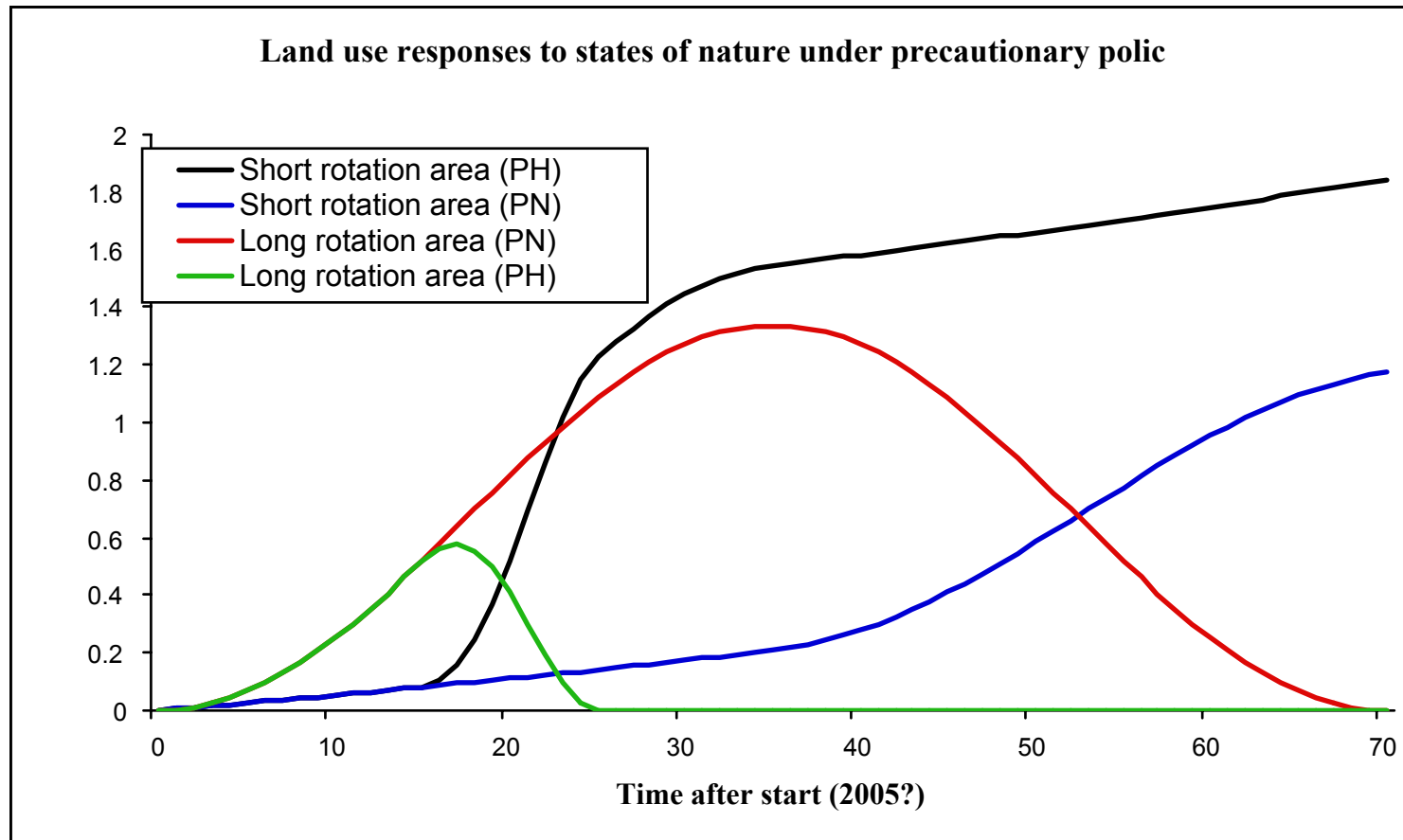
Another back of Envelope calculation

**Carbon in atmosphere under 'Manhattan Project' urgency
(in response to 'H')**

Area under long seq curve = ½ x 20yrs x .6 GHa x 3tC/Ha-yr = 18Gt C

Area under short rotation curve to 2030 =
$$\text{½ x 10 yrs x 1.2Gha x 10tC/Ha-yr = 60Gt C}$$
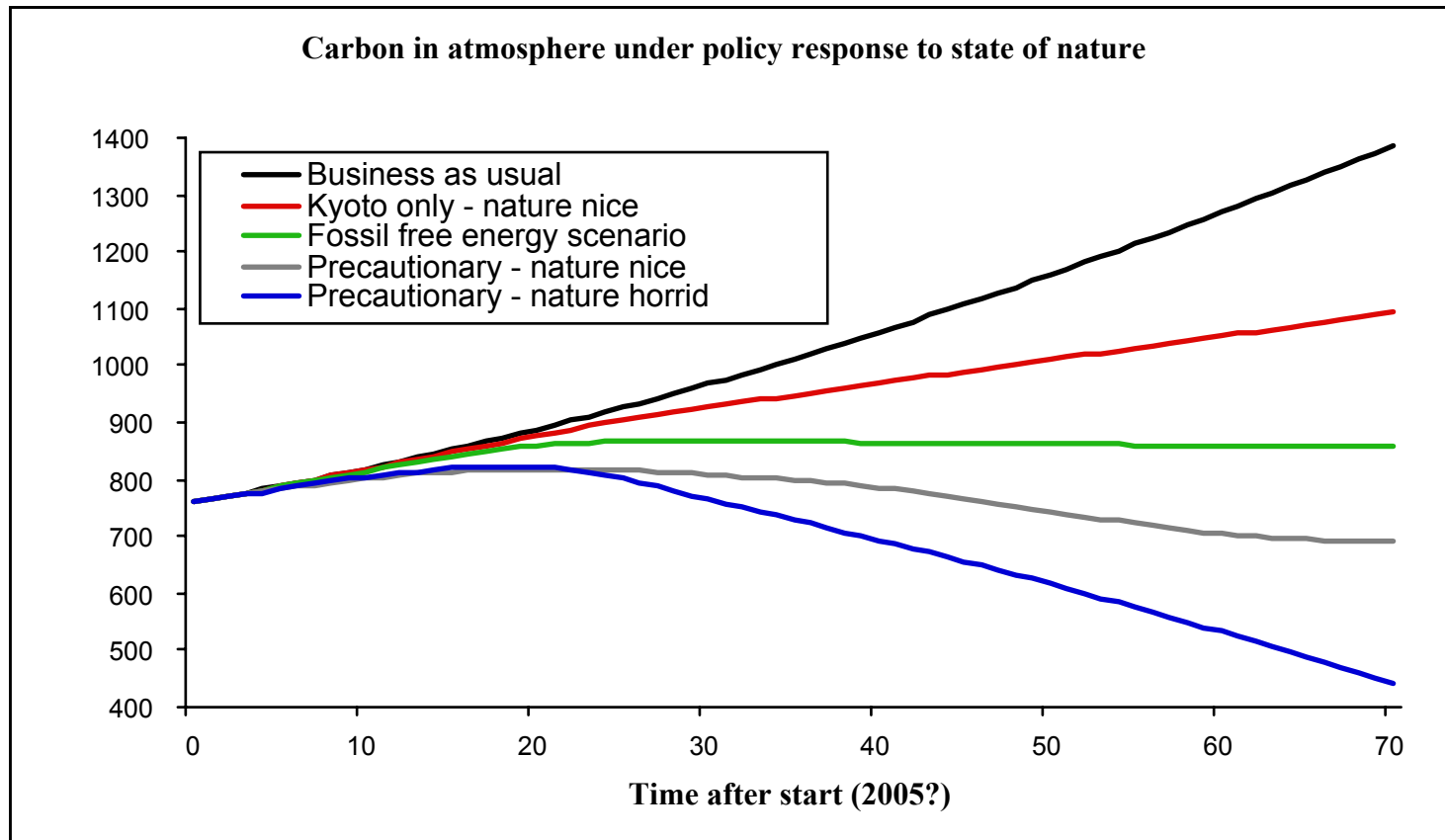
Assume 90 per cent replacement of Fossil fuel C emissions (see related
IAEE paper) = ~70 Gt C not emitted =
$$\text{35 ppm below "f.f.e.s." trajectory or ~400ppm}$$

By 2040 a further 10 yrs x 1.4Gha x 12tC/Ha-yr = ~150Gt C not emitted

Total = ~80 ppm below "Kyoto" trajectory by 2040. Remaining
reductions under 'Manhattan Project' urgency, as illustrated in fig 2, is
due to CCS technology used with fossil fuel point source emissions, to
increased energy efficiency and to more non-fuel renewables (wind etc.).

Gigatons C in atmosphere (= ~2 x ppm C_{at}) for three reference scenarios and with 'be prepared' policy related to 'Kyoto' case with and without response to ACC precursors after 2020. Note that negative emissions energy system is needed to get below 330ppm.

Carbon in atmosphere under policy response to state of nature

- Business as usual
- Kyoto only - nature nice
- Fossil free energy scenario
- Precautionary - nature nice
- Precautionary - nature horrid

Time after start (2005?)

Two Models

Common features of FLAMES (simulation) and LOLA (optimization)

Partial equilibrium approach modeling dynamic demand and supply in three markets:

- "Fuel": basic $C_xH_yO_z$ raw material with global current price ~$2/GJ.

- "Timber": basic timber product industry raw material price ~$130/ton
    after separation from joint product bio-fuel at process cost ~$90/ton.

- "Land": ~6bHa of non-barren, non conservation forest land that can be used
    commercially for farming or forestry or otherwise left to wilderness.

Demands grow with population and per-capita living standards; supplies of fuel and land
    products grow with technological progress.

Parameters are adjusted to achieve, in the without-policy case :

- Constant real prices broadly consistent with historic patterns

- Emissions paths to mimic reference case (i.e. no new scenarios)

Policy is represented by land allocations to two activities – long rotation plantations and short rotations which are both joint producers of timber and bio-mass for energy in proportions (different for the two activities) determined by relative prices.

Net policy costs are met by a tax on fossil carbon emissions.

Scenario	b.a.u.	f.f.e.s.	'Kyoto'
Parameter			
Growth of per capita fuel demand[a]	.0274	.0274-atp[b]	.0274-atp/2
Tech progress with fossil fuel supply	.035	.02[c]	.0275
Growth of fossil fuel emissions[d]	.015	0	.0075

[a] population increase averages .0076 (World Bank central projection) giving balanced supply and demand growth of 3.5 per cent and long term constant energy prices under b.a.u.

[b] accelerated technical progress with renewable energy and energy efficiency from year 10 to 30 with compensating later slowing to represent technical limits (see Read, 1999)

[c] fossil fuel research discouraged by policy, leading to more rapid cost increases

[d] assumes 2 % p.a. de-carbonization from fuel switching

<u>Manhattan Project style actions taken over the following decade in response to scientific news of Abrupt Climate Change precursors</u>

1   Retrofitting of all large point source fossil and bio fuel
        emitters with CCS technology
2   All new large fossil and bio fuel plant fitted with CCS technology
3   A system of gathering pipelines installed to collect captured CO_2
      and deliver to below ground storages
4   All long rotation policy land converted to short rotation mainly bio-fuel
      production with the part grown bio-mass material used wholly for biofuel
5   Shift from half to full atp for non-fuel renewable energy and technological
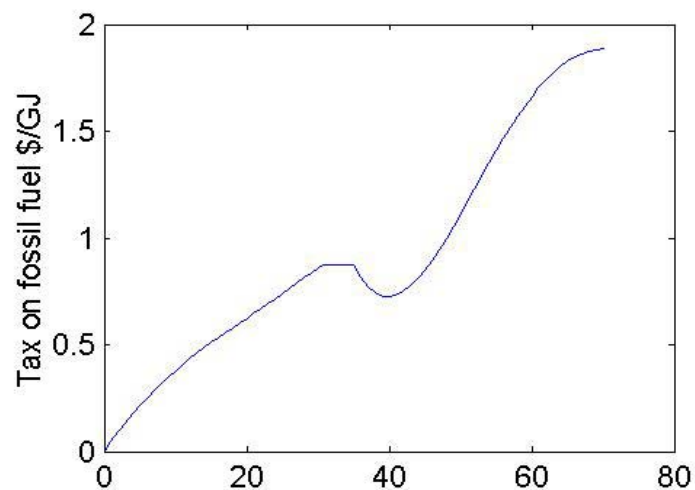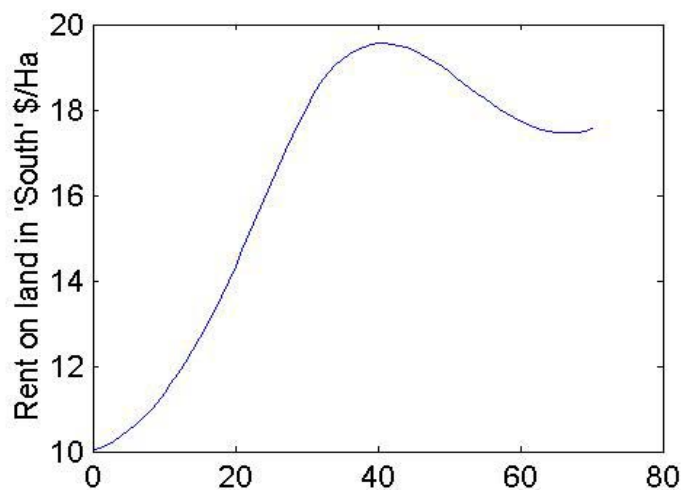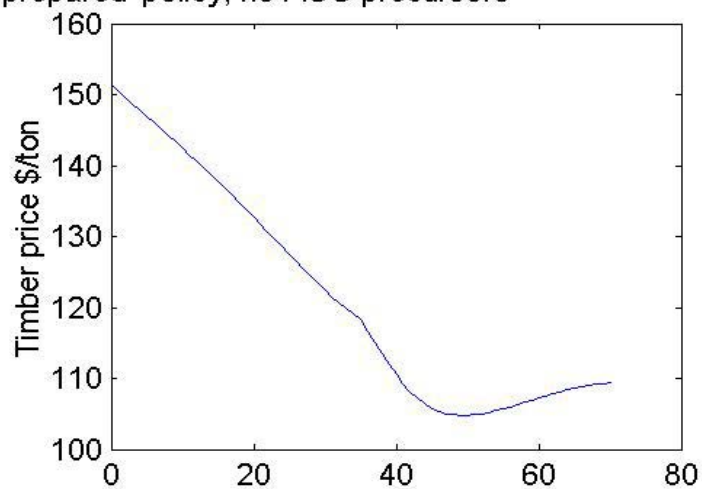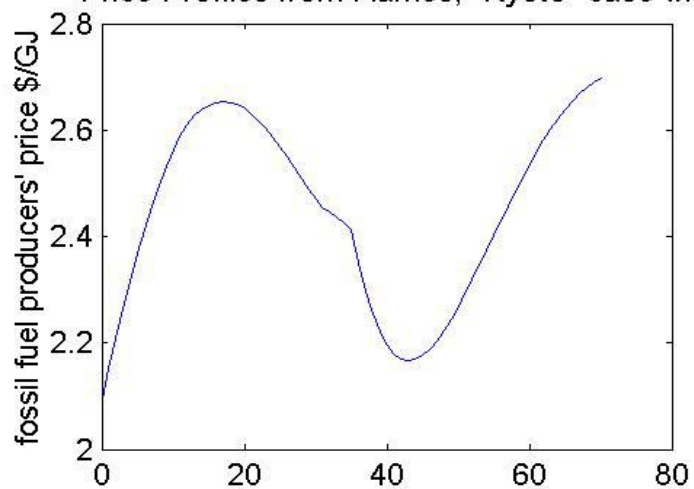   progress.

(These could be outcomes of shift to very high C-price, but other measures,
      such as absorption portfolios protect consumers and may be preferable)

The effect of these measures is that emissions per ton of fossil fuel fall from
      .025tC/GJ to .015tC/GJ and per ton of biofuel from zero to –
      0.01tC/GJ,with biofuel supply rapidly dominating the market.

FLAMES: progress, features and results

- Recent work has seen the development of multi-region models,

  with trade in fossil fuel, in bio-fuel, and in timber.

- Also of an ACC response variant of the global model. Here we report
  on the global model and this variant.

- Rotation lengths are fixed (35 years for long rotation = half the modeled
  time horizon, 1 year for short rotation)

- Technological progress is nil at 3tons C per Ha-yr for long rotation;

  rises from 6 to 18 tons C per Ha-yr for short rotation over 70 years

  (240 to 720 GJ/Ha cf current best commercial practice

  1300 for sugar cane, 1000 for eucalypt).

- Post-harvest land use
  is 50% to short rotation, 50% to farming for long rotation,
  100% to continued short rotation for short rotation

- Reference scenarios two cases considered mimicking, respectively,
  IS92 business as usual and Tellus/Greenpeace fossil free energy
  scenarios; "Kyoto" is treated as half way between

Price Profiles from Flames, "Kyoto" case with 'be prepared' policy, no ACC precursors

LOLA: progress, features and results
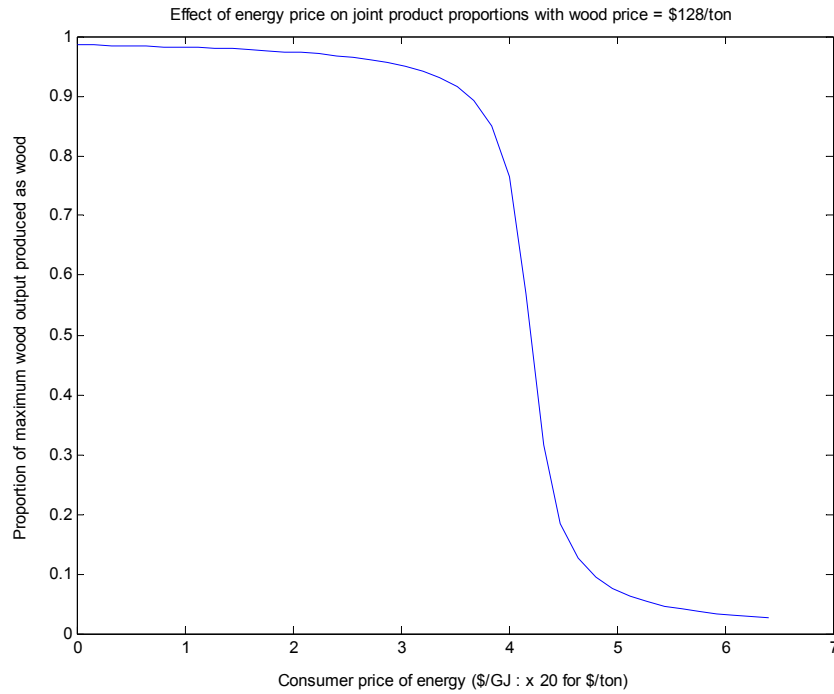
N.B. this presentation is subtitled

"<u>towards</u> incentive-compatible modeling of land use change policy impacts."

The implausible price profiles generated by FLAMES show need for optimizing model in which inter-temporal arbitrage (mediated by landowners' felling and replanting decisions) smoothes out the sharp shifts in price trends.
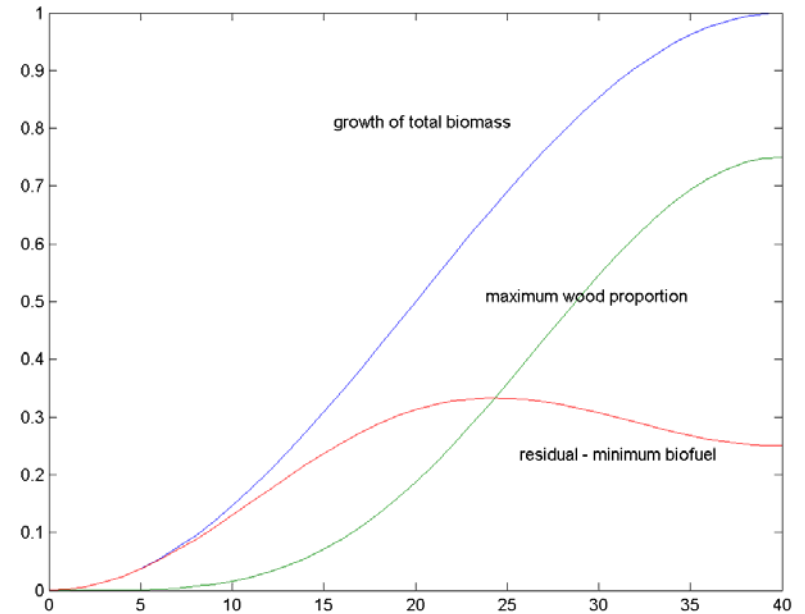
So far the behaviour of landowners growing existing forests and policy-induced long rotations has been modeled. Features include:

- Non-linear (S-shaped) growth of which a non-linear (S-shaped) proportion is usable as timber, but can be used for fuel, rising to 75 per cent of total biomass.

- After full growth in 40 years there is a plateau for 20, followed by linear decline (due to e.g. forest fires ?) over a final 40 years.

- Proportions of harvested woody material to each use is price dependent, as in FLAMES

- A tax transfer to meet costs of policy land planting and rents until end of land use change (35 years)

- Objective function is to maximize welfare (consumer surplus minus variable costs) implying price taking, jointly in the markets for timber and, in competition with fossil fuel.

- Landowners commercial rate of return is a constraint on welfare maximisation

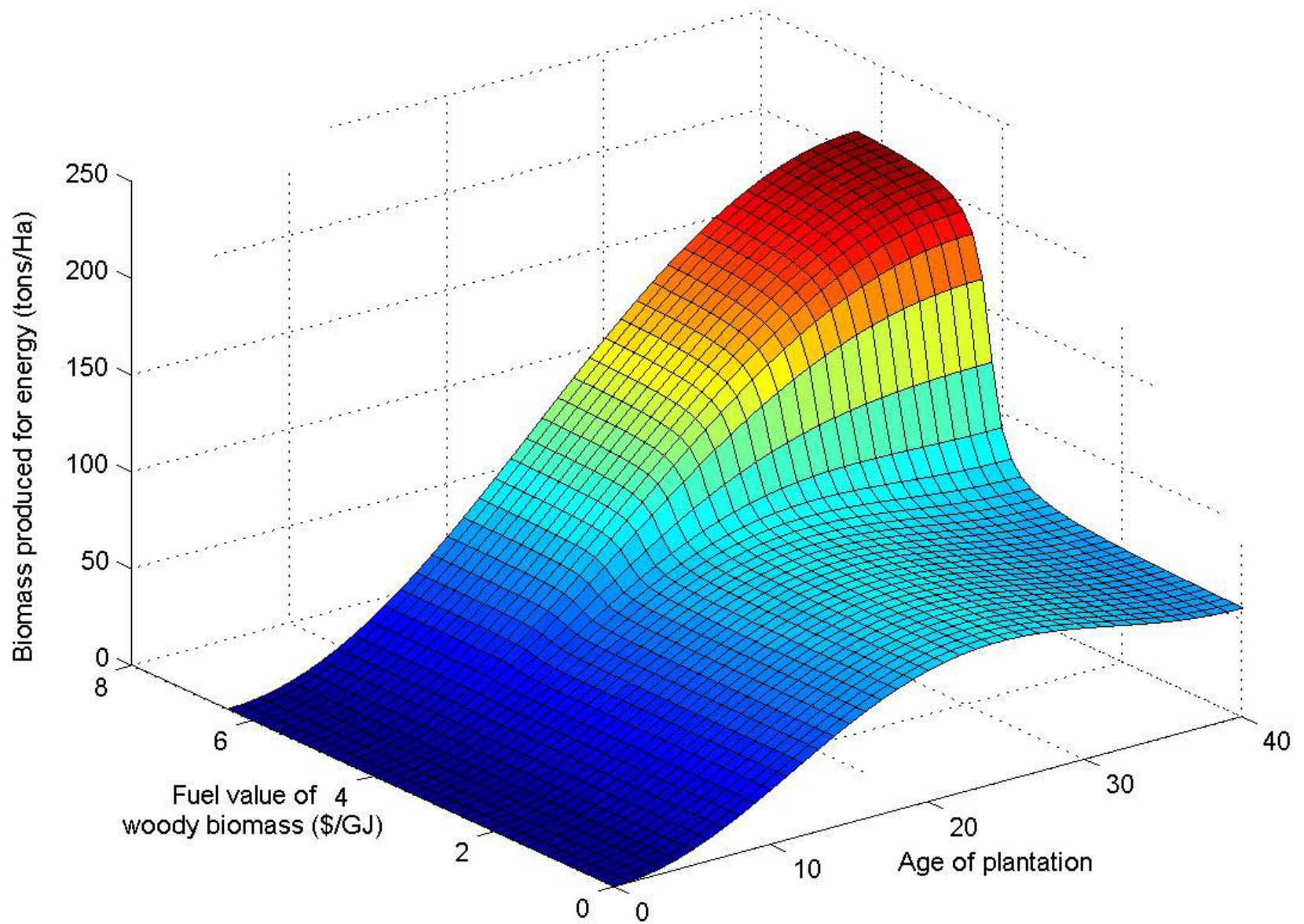# Relative Price and Age dependency of joint products of long rotation plantation

Effect of energy price on joint product proportions with wood price = $128/ton

Proportion of maximum wood output produced as wood

Consumer price of energy ($/GJ : x 20 for $/ton)

growth of total biomass

maximum wood proportion

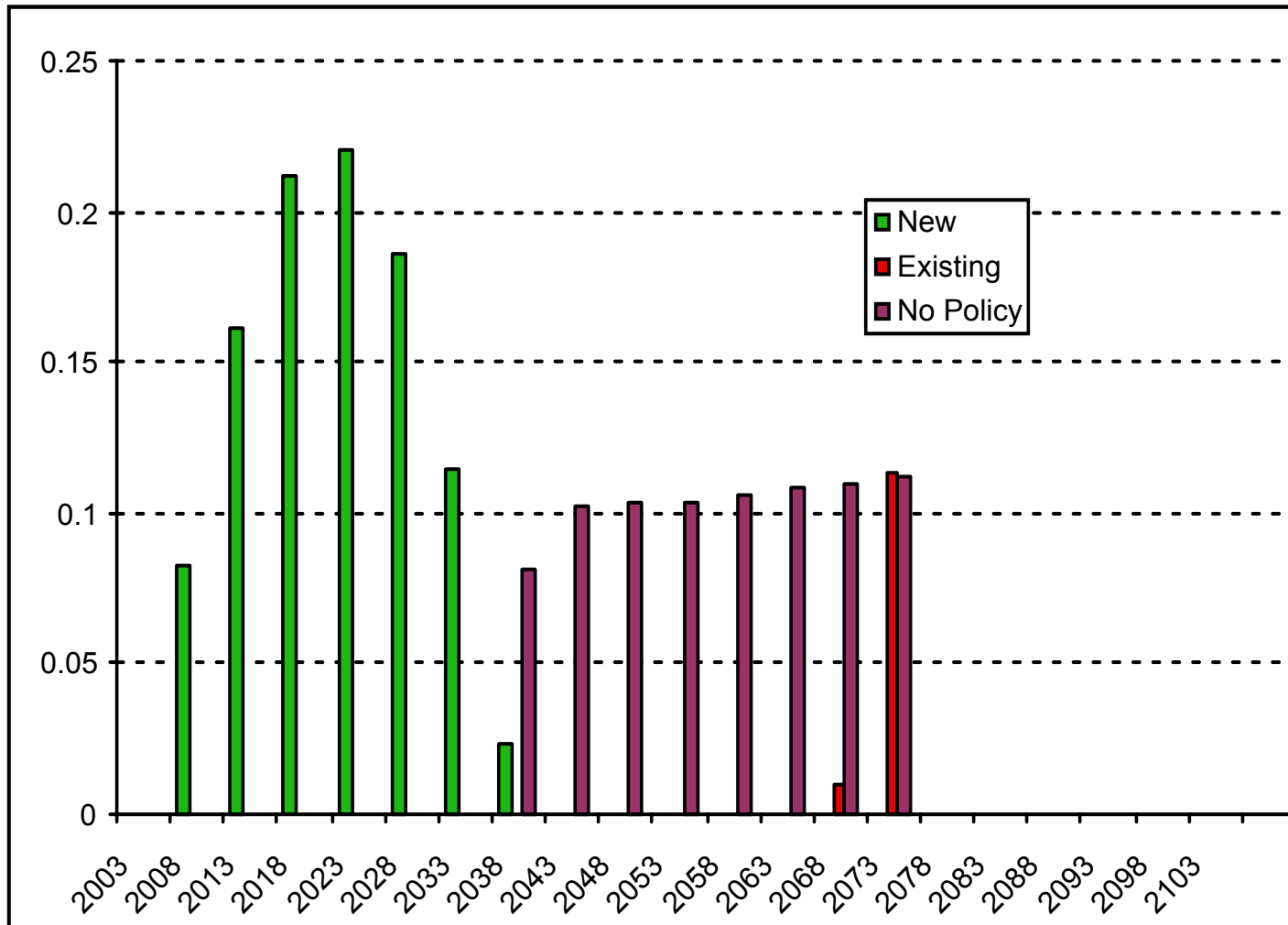residual - minimum biofuel

Price effect

Age effect

Woody biomass for energy, with wood value = 128 $/ton
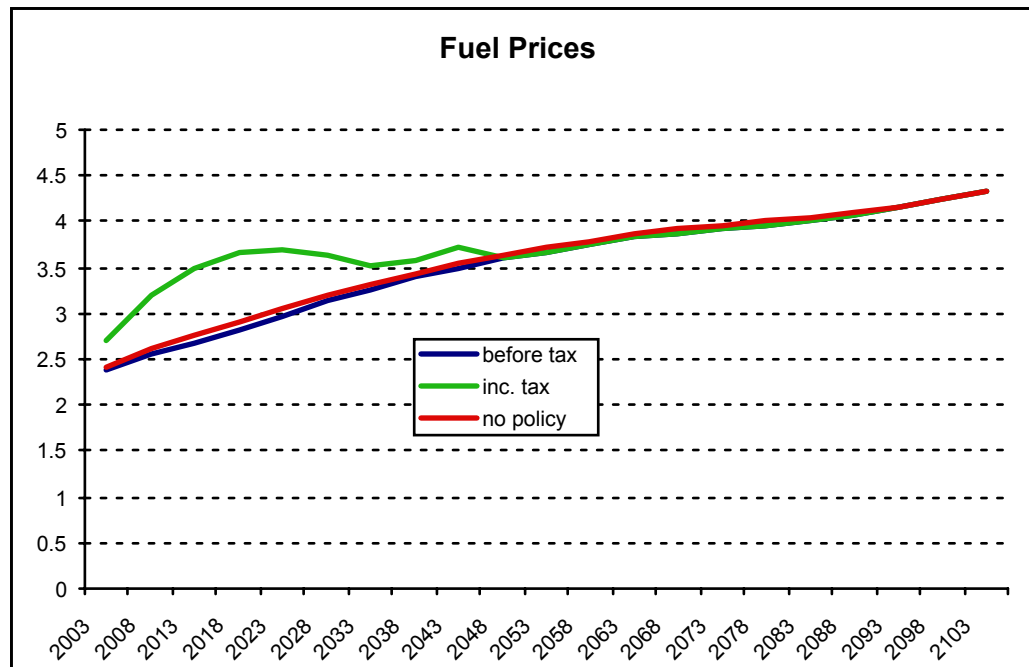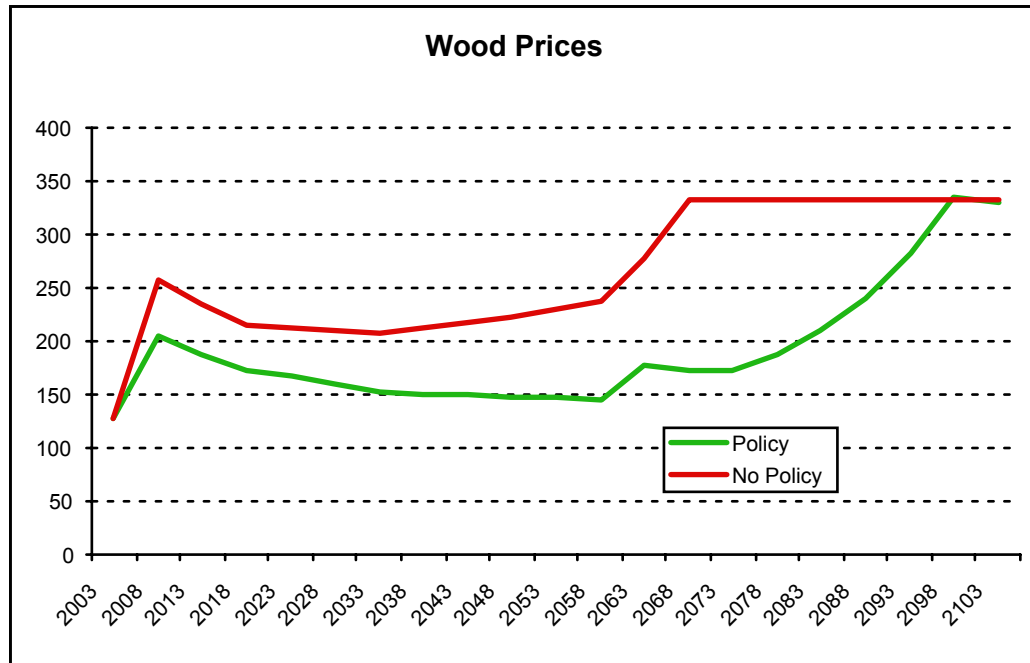
Planting

Price Profiles

fuel price with and without policy land at 10% commercial
return along with the policy transfer (fossil fuel tax) needed to fund
the policy – computation at 5 year intervals.

Price Profiles

Wood price with and without policy land at 10% commercial Return.

Provisional inferences

- Price profiles are smoothed out by optimizing behaviour.

- Policy driven land use change induces policy leakage through reduced replanting by existing foresters (this is anticipated in FLAMES).

- Providing landowners are price-takers, their required rate of return does not greatly impact on the pattern of harvesting and replanting.

Comments

The short rotation component of policy driven land use change has yet to be incorporated in the model.

The claim in the abstract regarding impact on carbon in atmosphere has yet to be substantiated but seems plausible given the assumptions that underlie the FLAMES modeling of this aspect.

Caveats

1. Optimization modeling (LOLA) in early stages

2. Low C_{at} levels require, in addition, high energy efficiency and increased use of non-fuel renewables as in f.f.e.s. scenario [but note that driven by ACC precursors not GCC as in f.f.e.s.]

3. Land use is assumed 'Maximal'
        [have you got a better guess?]

4. Need for capacity building

IN CONCLUSION: A question

Why, given its win-win-win-win potential, is the global bio-energy solution to the Climate Change issue ignored or down-played in policy formation ??

Win 1 –   early and effective stabilisation and medium term
                reductions in atmospheric carbon.
Win 2 –   potential to respond effectively to Abrupt Climate Change
Win 3 –   increased energy security and resistance to potential oil price increases
Win 4 –   sustainable economic prospects for landowners both in developed and
                developing countries

A Possible answer

- Market co-ordination failure between suppliers of bio-energy raw material and
        potential users separated by decades, oceans, language and culture

- Unfortunate self-perpetuating error in the negotiations [that ended, almost – i.e. all
        bar Russia – at Marrakesh] due to maintained assumption that best policy is
        to price up carbon through TEPs, ignoring need to drive technology change.

Maybe it's time to try again in context of Art 3.3 of the 1992 Rio Convention, looking at the grounds for early action provided by threats of ACC.
If so, it is hoped that these models towards a better outcome second time round